SECTION A, BIOLOGICAL SCIENCES

SUBSECTION ZOOLOGY

The Recent Gastropoda of Oklahoma. Part I, Historical Review, General Comments and Higher Taxonomic Categories.*

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The compilation of molluscan species lists for the tract of land at present encompassed by the political confines of Oklahoma was started by Simpson in 1888. Simpson, as well as most other early workers, listed shells obtained near railroad stops. Consequently, the type localities for the few snails which have been described as new from Oklahoma are still easily revisited. Thirty-four forms were listed in this first paper, to which Pilsbry (1899, 1903) appended additional data from the same localities. New localities, species and subspecies were described by Ferriss (1900, 1906), Pilsbry (1902) and Pilsbry and Ferriss (1902). The last cited paper is the most intensive work on Oklahoma gastropods, though concerned only with a localized area.

Until 1944 only five other papers were published with bearing upon the fauna: Walker, 1909; Baker, 1909; Walker, 1915; Greger, 1915; and Isely, 1924. Leonard and Franzen (1944, 1946) contributed two short but very interesting papers concerning fossil Gastropoda (mostly Lower Pliocene) which give us some insight as to the origin of our fauna. A third and longer paper materially added to the knowledge of Oklahoma gastropods. (Franzen and Leonard, 1947).

Most of the later publications (simple lists) on this problem are mentioned here without comment: Lutz, 1950; Wallen, 1951; Wallen and Dunlap, 1953; Webb, 1953a and b; Dundee, 1955; Dundee and Dundee, 1958; Branson and Wallen, 1958; and Branson 1959a and 1959b (in press).

GASTROPOD PROVINCES OF OKLAHOMA: Oklahoma, according to Dice (1943) and Blair (1950), includes parts of five biotic provinces, all of which lie in the Eastern Molluscan Division of Henderson (1931). This division is distinguished from its western counterpart by the absence, in the latter, of the molluscan genera *Campeloma, Viviparus, Pleurocera (sensu stricto)* and *Lioplax*. In addition, there are many species and sub-

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species of *Polygyra* and *Goniobasis* aggregated in the Eastern Division as contrasted to the relatively few members of these genera in the west. The arbitrary dividing line of Henderson's divisions, starting at the Canadian border, begins approximately at Longitude 108° West, loops eastward to exclude the Black Hills of South Dakota, follows the eastern border of Wyoming, then passes through eastern Colorado and New Mexico into Mexico.

Provincial lines, as delimited by most authors, are subjective in the extreme. The only two provinces which actually approach nonintergrading distinctiveness are the Navahonian and the Austroriparian, both of which barely enter Oklahoma. In the three large subdivisions (Kansan, Texan and Carolinian) one finds a rather definite east to west gradient of characters, mainly as a result of finger-like extensions of forests along stream margins and a definite east to west moisture cline of an increasingly negative nature. These streams, perforce, afford excellent migratory routes for many mollusks, as well as other animals. Furthermore, ecological islands considerably modify the demarcation lines of any biological province. Nonetheless, it is in a degree possible to recognize areas in which faunas are in some sort of ecological rapport with the totality of ecological conditions contained therein. In the following discussion the only animal forms considered are gastropods, since Blair and Hubbell (1938) and Dice (1943) have discussed other forms in some detail.

The Navahonian (Mesa da Maya Biotic District of Blair and Hubbell), as intimated above, is found only in the extreme northwestern part of Oklahoma (Black Mesa). The mesa is composed of Dakota Sandstone capped with a fairly thick layer of basaltic lava. The average temperature is relatively mild (54.8°F.) and the average precipitation low (17.9 inches). Plant associations are typical of the semi-arid regions (short grasses) except for some mountain holly, juniper, hackberry and Pinyon pine. The live oaks reported by Blair and Hubbell (1938) are relatively scarce. The maximum elevation of the mesa (actually an incursion of the Rocky Mountain Uplift System) is just under 5000 feet, which is the greatest elevation in the state. There are several perennial springs in the numerous canyons. In the immediate vicinity of the springs grasses and sedges grow rather luxuriantly.

The molluscan fauna of this province is not at all characteristic of the general foothills of the Rocky Mountains, with one or two generic exceptions. The genus *Pupilla*, a taxon usually found in cool, humid situations, may be thought of as a Pleistocene relict in Oklahoma. Members of this genus (*P. muscorum* and *P. blandi*) may be found associated with *Gastrocopta* spp. and *Pupoides albolabris* under the matted grasses near the springs mentioned above. This area is in need of additional investigation.

Over half of Oklahoma is included in the Kansan Biotic Province. The eastern borders of this area extend diagonally through the central tiers of counties, the entire western part of the state, excluding the Mesa de Maya, possessing characters supposedly holding its flora and fauna together. This province has been subdivided by Blair and Hubbell into three districts which are fairly distinct, at least as far as plants are concerned, and one district that is not so distinct. The mixed-grass plains district includes most of western Oklahoma except the panhandle. Most of the surface consists of Permian Redlands with some gypsum protrusions such as those in Major County. The average annual temperature varies from 58.6° to 62.7° F. and the average rainfall from 26.8 to 27.6 inches. The latter is a rather ambiguous statement, for as observed by Blair (1950) and Branson (1959b), there is a distinct east to west moisture gradient in this district. Along streams there are some extensive sand dune areas

inhabited by cottonwoods and tamarix and in some areas isolated hardwood associations, as in Caddo Canyon, are formed.

The mixed-grasses grade into the short-grass district of the panhandle in Harper County. The eastern boundary of this district is distinctly correlated with depth of underlying salt deposits (indicated by a slight escarpment at about the 100th meridian) east of which the grasses tend to be tall rather than the characteric short species in the west. The area includes Permian deposits overlaid by Tertiary formations. Also included are areas that are rapidly becoming biological deserts as the result of overgrazing, improper tilling practices, and the prevailing winds. Some of these eroded areas are practically devoid of plant or animal life.

In extreme southwestern Oklahoma (Southern Harmon and Jackson counties) the so-called mesquite biotic district occurs. About the only character which distinguishes this district, at least in Oklahoma, is the presence of *Prosopis glandulosa,* the mesquite. It otherwise very closely resembles the short-grass district.

Extending from Ft. Sill to approximately Granite, Greer County, the Wichita Mountains are entirely surrounded by mixed-grass plains. Many of the summits are barren rock and the lower slopes bear only a thin mantle of soil. In general, however, enticing as it may seem to read distinctiveness into the district, it is most difficult to separate the flora of the Wichitas from that of the mixed-grass plains. The streams, however, are clear and spring-fed, lending some relief from the turbid conditions of the plains. The Wichita district does not seem to contain an endemic molluscan fauna. In fact ,the whole Kansan Province is rather general as regards its mollusks. In the western Kansan, *Valvata tricarinata* has been reported once (scarcely enough to characterize such an extensive tract of land) and in the short-grass area *Oxyloma decampi, Planorbula* and *Armiger* have been considered as characteristic, but *Oxyloma* is the only one of these that is frequently found. In the mixed-grass district, *Strobilops labyrinthica* is characteristic of the stream-bed incursions and cross-timbers, whereas *Polygyra texasiana* and several species of *Gastrocopta,* especially *G. armifera* and *G. procera* of the plains proper. *Discus cronkhitei* is apparently restricted to the short-grass region, though almost assuredly it occurs also in the Navahonian; *Physa anatina* is about the only snail exclusively characterizing the whole Kansan Province. The outstanding reasons underlying the difficulty in classifying biological districts in this area are the fingers and islands of forests which extend westward. These tracts of vegetation form virtual freeways allowing eastern forms migratory routes to the west (Branson, 1958).

The Texan Province of Dice and Blair is somewhat more easily characterized. Its western boundaries, as delimited by Blair and Hubbell (1938), extends northward from the eastern border of Jefferson County through north-central Osage County. Its eastern limits are formed by the Neosho (Grand) River in the northeast, south of which a finger of the Texan extends eastward almost to the Oklahoma-Arkansas border. A well-developed district of the Carolinian Province (the so-called Ouachita district) interdigitates with the Texan south of the above-mentioned eastward extension. This district merges with the prairies near Atoka. The southeastern limits are set by the Austroriparian. This line extends from about Shawneetown northward to south and east of Wright City (both in McCurtain County) where the line meets the southern border of the Ouachita biotic district. The area delimited above includes two biotic districts of Blair and Hubbell: the Osage district and the Cherokee prairie district.

The physiography of the Osage is one of unevenness, rounded hills

covered by tall grasses, some eroded ridges, oak-hickory associations, and western and eastern cross timbers. As pointed out by Blair, this is essentially an area of intergradation.

The gastropod fauna of the Osage is not particularly distinctive as there is extensive intermingling of species from the east and the west. In the cleared, cooler streams, such as the Blue River in Johnston County, Honey Creek above Turner Falls and Bird Creek and its tributaries in Osage County, members of the family Amnicolidae are not uncommon. However, these species are incursions from the east and not distinctive. *Oligyra* is common from the western border of the Texan throughout eastern Oklahoma. The western line of the Texan is approximately the eastern limits of the Vallonidae, with a few exceptions where conditions are approximate to the conditions west of the line. With the exception of a single record in Blaine County, the genus *Bulimulus* is restricted to counties east of a line drawn through Stillwater, Payne County, and paralleling the Texan province boundary. In the Texan, and the two eastern Provinces the genus is common. *Polygyra dorfeuilliana* is the most common polygyrid in the southeastern Texan, being replaced in a degree by *P. texasiana* in the west and central parts of the Province. *P. dorfeuilliana* does, however, occur in insular loci where conditions permit. *Anguispira alternata* is a charactertistic species in all of Oklahoma east of a line drawn through Kay and western Murray counties, but is such more frequently found in uplifted areas. *Striatura meridionalis,* whose type locality lies just at the western edge of the Texan at New Braunfels, Texas, is probably the most distinctive species of this Province. Like the other species, it also forms insular colonies east and west of this ecological type.

The Cherokee district is not particularly distinguishable from the rest of the Texan except that there is some spillage from the Ozarkian on its extreme eastern border. This is discussed further below.

In Oklahoma the Austroriparian Province is synonymous with the Mississippian biological district of Blair and Hubbell. The limits of this district have, however, never been satisfactorily set. The western intergradation line extends northward from the Red River through Shawneetown to an area just south of Wright City, then follows an undulating line across lower Glover Creek, passes above Broken Bow, then follows a course slightly above Eagletown into Arkansas. These lines are, of course, arbitrary, as are those of any other such artificial delineation.

The area, with an average rainfall slightly in excess of 46 inches and entirely included in southeastern McCurtain County, is characterized by sweetgum, sourgum, palmetto, holly, several oaks, red maple and many other trees. There are also heavy stands of pine. In the forested areas the undergrowth often forms an almost impenetrable thicket. The floors are deeply covered by deciduate leaves, pine needles, molds, ferns, fragments of dead plants and other organic debris and are well-shaded by the canopy above. If it were not for the lack of limestone in the soils, which are mostly cretaceous depositions (sands and clays), these forests would probably boast a very heavy molluscan fauna. That is not to say snails are absent, but there is no comparison with the fauna in comparable areas in the Carolinian.

The streams, as pointed out by Blair and Hubbell, are generally sluggish. Many of them, for example Yashau, Boctukulo, Luksukulo and Waterfall creeks, cease to flow entirely during the hot, humid summer months. A few of the streams are relatively turbid but most are fairly clear. The banks are of mud and usually heavily vegetated with *Cephalanthus, Salix, Juncus, Scirpus, Eleocharis, Dianthera, Taxodium, Hydrocotyl, Hydrolea* and many other plants. The tributary streams to the Red River and to the Little River often have mud bottoms mixed with gravel

and small boulders. Little River itself has stretches of similar bottom, but is more characteristically enclosed in rather narrow channels (except at flood stage) composed of rubble, gravel and boulders. At places *Dianthera* nearly obscures the water from sight. In the quiet waters, the surface of the river, especially of the tributaries, is heavily covered by mixtures of *Spirodela, Lemna,* fern allies and algae. Near the mouth of the Mountain Fork River the bottom of the stream is quite often heavily covered with horned pondweed, *Zannichellia palustris.* Soil and organic material collect around the roots of the plant forming micro-habitats which are inhabited by the only species of gastropod *(Campeloma decisum)* characteristic of the Oklahoma Austroriparian. *Campeloma* is found only in this well-defined area (in Oklahoma) and is restricted to the mud-bottomed streams, or the micro-habitats formed by plants (described above), and in the bud-bottomed oxbow lakes such as Grassy Lake.

There remains to be discussed a single province—the Carolinian, which Blair and Hubbell have subdivided into two biotic districts: the Ouachita district and the Ozarkian district. The former is only a partially distinct entity. The Ozark district probably possesses the sharpest demarcation of any district in the state. The western limit of this area is sharply delimited by the Neosho (-Grand) River. The northwestern boundary is coincident with the eastern boundary of the Cherokee prairie district and the central and southwestern border with the Osage Savanna (all, of course, impinging upon the eastern shores of the Neosho River and Grand Lake). The region abounds in Boone chert and limestone, mostly of Mississippian or Pennsylvanian age. The average annual rainfall is about 43 inches. The terrestrial cover east of the Neosho is characterized by oak-hickory associations, maple, cottonwood, considerable sycamore and willow. Blair and Hubbell remarked upon the sparsity of litter and soil mantle in this district, but this is a generality and not entirely true. Spring Creek in Mayes County, Lost Creek and the Elk River in Ottawa County and several streams near Tahlequah and Ft. Gibson in Cherokee County have bluffs overlaid with rather thick deposits of rich, perennially moist layers of leaf mold. All of these forested areas are fairly well shaded by the canopy.

The streams are nearly always relatively swift, clear, and possess many riffles and pools. The beds are mostly of gravel, sand and small boulders. They are mostly spring-fed and slightly alkaline (Branson 1959b). The riffles are usually heavily covered with *Cladophora* and mosses. Many of the clear pools have two or more species of *Potamogeton, Nuphar, Nymphaea,* large beds of *Nasturtium,* a species of *Callitriche,* some *Jussiaea, Myriophyllum,* and areas of dense growth of *Ceratophyllum.* The shores, in addition to the typical terrestrial plants, bear several emergents such as *Sagittaria, Eleocharis, Scirpus, Juncus, Carex* and *Cyperus,* and often dense stands of *Hibiscus militaris* and *Cephalanthus occidentalis.* Many of the streams are underground and large numbers of small tributary streams head in springs which drip down over dense mats of algae and mosses on cliffs.

The gastropod fauna in this area is the richest in the state and there are several endemic species and subspecies. These forms originated, according to Pilsbry and Ferriss (1906) by radiation from the Tertiary Appalachian Mountains. It is obvious, from such works as Franzen and Leonard (1947) that the Pleistocene did not have a marked effect upon the fauna of this district (relative non-abundance of boreal and dryer Sonoran forms). The Neosho River is apparently a fairly stringent isolating barrier to invasion by the Cherokee terrestrial snails. Pilsbry and Ferris (1906) listed three races of *Polygyra dorfeuilliana* as being distinctive of the Ozarkian. However, I consider the subspecies *sampsoni* to be more typical of the wooded ravines, stream margins and moist hills along

streams in the Texan and *P. dorfeuilliana percostata* more typical of the Ouachita district. This leaves *P. d. perstriata* as the typical form of the Ozark district. *Polygyra jacksoni* and its three nominal subspecies are entirely restricted to the Ozark district. One other terrestrial gastropod, *Philomycus carolinianus,* which is usually found on the chert outcrops at night, is restricted to the Ozark region (in Oklahoma). Only two aquatic species, which I recognize, are peculiar to the Ozark district. *Mudalia (-Goniobasis) plebia* is found in almost every cool, clear stream in the entire district and seldom, if ever, elsewhere. *Ferrissia tarda* is the second of the two species and may be found crawling about in quiet pools or at the edge and foot of riffles on aquatic vegetation or bare rocks.

The Ouachita district of Blair and Hubbell consists of the Ouachita Mountains. I, among others, consider this district to be a part of the Carolinian and separable from the Ozarkian only with some difficulty. It is essentially an area of intergradation of types. Its flora is, in general, a mixture of the Ozarkian to the north, Texan on the north, west and southwest and Austroriparian on the southeast, and a mixture of the Texan and Ozarkian centrally. The only gastropod that is actually restricted to its confines is *Mesodon kiowaensis,* the rarest of North American mesodons, found in and around Pittsburg County (Kiowa, Gap, etc.). There are, however, several species which are shared by these two districts (Ozarkian and Ouachita) and restricted to them. The following is a fairly representative list: *Mesodon indianorum, M. divesta, M. zaleta, M. cragini. Triodopsis albolabris,* and the genus *Mesomphix.* Both districts are rich in individuals of *Oligyra* and species of the family Lymnaeidae.

SYSTEMATICS: HIGHER CATEGORIES AND FAMILIES.

The Gastropoda of Oklahoma are rather unevenly divided into two subclasses: the Prosobranchia and Pulmonata. Of the two taxa, the first is considered by most authorities to be the more primitive. Members of the Prosobranchia are easily recognized by the presence of an operculum (Plate I, Fig. 5; Plate III, Fig. 14b), a structure which none of the Pulmonata possess. The subclass Prosobranchia includes three orders, two of which have representatives in our fauna. The order Archaeogastropoda may be distinguished from the order Mesogastropoda by characters either of the shell or of the soft anatomy. The Archaeogastropoda is represented in Oklahoma by *Oligyra orbiculata tropica* (Pfeiffer) Plate II, Fig. 1). Since nearly all members of the prosobranchiate gastropods are aquatic and bear gills, this species is unique in our fauna as it is terrestrial and abranchiate, with the mantle cavity modified as a "lung." The shell is moderately heavy and globose with a broadly rounded periphery. Typically, a blunt projection is borne at the thickened base of the columellar lip. The operculum is a simple structure, usually orangish in color and without apparent spiral structure.

The order Mesogastropoda contains our aquatic operculate forms (Plate II, Figs. 2 a, b, c; 8). All of these are separable at sight from the terrestrial form briefly discussed above. All members of this order bear a gill possessing a single row of gill-leaflets. Their shells are usually thin with a simple, nonthickened lip. However, some do have a relatively thick shell, with whorls moderately to strongly shouldered (instead of being broadly rounded) and a thickened lip. Some members of this order are quite conispiral; none possess a blunt projection on the columellar lip. Nine species are presently known from Oklahoma.

The subclass Pulmonata is usually divided into two orders, both of which are represented in Oklahoma. In the order Stylommatophora the eyes are situated at the tip of the posterior tentacles (Plate I, Fig. 3), whereas, in the order Basommatophora, they are located at the base of the posterior tentacles. However, with only the shell at hand, ordinal

diagnosis becomes slightly more difficult. Basommatophorans are, with the exception of *Carychium exile* (Carychiidae) (Plate II, Fig. 3), all aquatic. The remaining families of the Basommatophora found in Oklahoma are: Planorbidae (Plate II, Figs. 10, 11), Lymnaeidae (Plate II, Fig. 6a, b, c), Physidae (Plate II, Fig. 4) and Ancylidae (Plate II, Fig. 5). All of these and 11 stylommatophoran families are treated in the following key. However, since *Pseudosuccinea columella* (Say) (Plate II, Fig. 6a) is easily confused with some succineids (Plate II, Fig. 6, b, c) the following morphological details are offered in order to facilitate proper identification (Table I).

TABLE I

Comparative modal measurements (mm.) in *Pseudosuccinea*, *Succinea* and *Oxyloma*. Figures in parentheses represent ranges (See also Plate I, Fig. 4)

	Modal Length Spire		Total Modal Length		Modal Length Body Whorl Modal Length Aperture	
P. columella	1.05	(0.6-1.9)	10.01	(7.2-14.0)	1.28	(1.09-1.10)
S. avara	1.02	(0.7-1.3)	9.78	(7.5-11.1)	1.32	(1.20-1.41)
**Succinea*	1.77	(1.0-2.7)	10.44	(7.1-13.0)	1.39	(1.32-1.50)
Oxyloma	1.34	(0.9-2.0)	10.30	(7.0-15.0)	1.33	(1.25-1.53)

*Other than *S. avara*

However useful the above criteria are, there is considerable overlap in all of these figures. From this, it is apparent, that the shell of *Pseudosuccinea* is not particularly useful in separating this species from its analogs in the Succinaeidae. The species is easily distinguished by other features from those species with which it is commonly confounded. As indicated above under the order Basommatophora, the eyes in *P. columella* are situated at the base of the posterior tentacles whereas they are at the tips of these tentacles in succineids (Plate I, Fig. 3). In addition, the jaw (Plate I, Figs. 1, 2), a sclerotized structure which opposes the radula, is quite final in separating the two families. This structure as well as the radula, may be easily removed by decapitating the snail in question and gently boiling the head in strong KOH until the flesh falls away easily upon the touch of a dissecting needle. The teeth and jaws may be stained with mercurochrome and mounted in a suitable medium, such as Canada Balsam or polyvinyl alcohol.

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KEY TO THE FAMILIES

1. Shell external 2
   Shell internal or absent (slugs) (Plate II, Fig. 7a, b) 20
2. Shell with an operculum 3
   Operculum lacking 8

3. Operculum concentric (Plate I, Fig. 5a; Plate III, Fig. 14b) 4
   Operculum spiral (Plate I, Fig. 5b) 6
4. Length of aperture ⅔ or more of total length (Plate II, Fig. 8) ..... **Ampullariidae**
   Length of aperture not more than ½ of total length 5
5. Shell globose with broadly rounded periphery; color whitish; lip very thick, a blunt projection at base of columellar lip (Plate II, Fig. 1) ..... **Helicinidae**
   Shell not globose, color horn or greenish; whorls definitely shouldered; lip thin, projection lacking at base of columellar lip (Plate III, Fig. 14a, b) ..... **Viviparidae**
6. Adult shell less than 10 mm. long 7
   Adult shell more than 15 mm. long (Plate III, Fig. 12) ..... **Pleuroceridae**
7. Operculum circular and multispiral. Shell less than 7 mm. long with dorsal, lateral and ventral carinae (Plate III, Fig. 13) ..... **Valvatidae**
   Operculum not circular and multispiral. Shell slightly larger, less than 7 mm.; no salient carinae (Plate II, Fig. 2) ..... **Amnicolidae**
8. Shell both conispiral and sinistral (Plate II, Fig. 4) ..... **Physidae***
   Shell not both conispiral and sinistral 9
9. Shell lacking whorls; patelliform (hat-like) (Plate II, Fig. 5) ..... **Ancylidae**
   Shell possessing definite whorls; shape variable 10
10. Shell ultrasinistral or ultradextral; spire sunken below other whorls (orb-like or discoidal) Plate II, Figs. 10, 11) ..... **Planorbidae**
    Shell not ultrasinistral or ultradextral; spire never sunken below other whorls 11
11. Shell pupiform, much longer than wide, cylindrical to narrowly-conical (with several short whorls; aperture about as wide as high) 12
    Shell discoidal, lymnaeiform or conical; never greatly longer than wide 13
12. Shell white, very slender, definitely conical and tapering; 1.7 to 1.75 mm. long; diameter about 0.6 mm.; a single tooth near columellar lip; lip thick (Plate II, Fig. 3) ..... **Carychiidae**
    Shell brownish, ovate-conic to cylindrical, diameter generally more than 0.6 mm. (0.75 to 2.4); teeth variable, but never with a single tooth near columellar lip; lip thickened or not (those without teeth much larger than above, about 5 mm., or with a thin lip) (Plate III, Figs. 3; 4a, b, c) ..... **Pupillidae**
13. Shell discoid-conical (trochiform); deeply umbilicate; wider than high; lip thickened and reflected; two or more long entering lamellae (Plate III, Fig. 1) ..... **Strobilopsidae**
    Lacking this arrangement of characters 14
14. Shell discoidal, flattened; very widely umbilicate; lip nearly circular, much thickened, toothless; fine membranous ribs on whorls; whorls slightly over three Plate III, Fig. 2) ..... **Valloniidae**
    Never with these characters 15
15. Shell conispiral (nearly all lymnaeiform) 16
    Shell discoidal or helically coiled 18
16. Shell wide, globose-conic, thin; streaked with opaque white or brown on grayish background; length 18 to 25 mm. Plate III, Fig. 5) ..... **Bulimulidae**
    Shell narrower; seldom streaked or mottled 17

17. Shell very thin and non-umbilicate (anomphalous); about 4 whorls; spire usually short; lip thin and simple; color yellowish; aperture occupying ½ or more of shell length; whorls not shouldered Plate II, Fig. 9a, b) ..... **Succineidae****
Shell thicker, umbilicus usually present; 4 to 8 whorls; spire more or less elongate; color brownish to brownish-white; aperture usually occupying less than ½ of total length; whorls shouldered (Plate II, Fig. 6a, b, c) ..... **Lymnaeidae**

18. Lip reflected or turned back, often toothed; shell discoidal-globose to lens-shaped Plate III, Figs. 15a, b; 16) ..... **Polygyridae**
Lip not reflected; shell helically coiled 19

19. Surface of shell dull, coarsely ribbed; very flattened or distinctly marked by brownish striations Plate III, Figs. 7, 9, 10) ..... **Endodontidae**
Surface of shell polished, never coarsely ribbed; a low conoid spire; unicolored Plate III, Figs. 6, 8, 11) ..... **Zonitidae**

20. Mantle covering only forward part of back 21
Mantle covering entire back (Plate II, Fig. 7a) ..... **Philomycidae**

21. Pneumophore behind the mantle groove (Plate I, Figs. 6b; Plate II, 7b) ..... **Limacidae**
Pneumophore in the mantle groove (Plate I, Fig. 6a) ..... **Arionidae**

* One species in the Pupillidae is also both spiral and sinistral, but it is much smaller and has the typical pupiform shell.

** The genus *Pseudosuccinea* will key out in this family. See the discussion under Basommatophora.

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FIG. 1

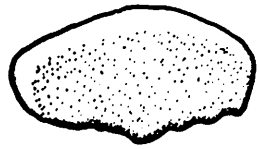


FIG. 2

FIG. 3

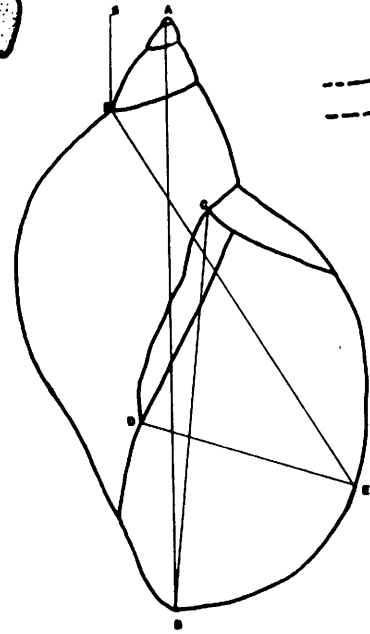
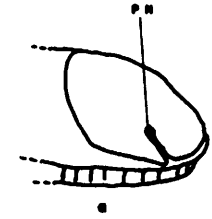


FIG. 4

a



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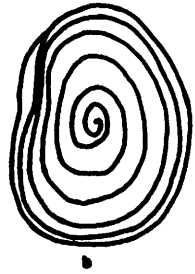
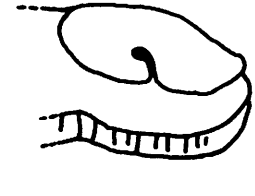


b

FIG. 5



b

FIG. 6

PLATE I

Figure 1. Jaws of succinaeids.
a. *Succinea grosvenori* Lea
b. *Succinea avara* (Say)
c. *Oxyloma* sp.

Figure 2. Jaw of *Pseudosuccinea columella* (Say)

Figure 3. Tentacles and eyes of *Succinea*. PT, Posterior Tentacle; AT, Anterior Tentacle

Figure 4. Shell measurements in succinaeids and *Pseudosuccinea*. A-B Height; B-C, Apertural Length; D-E, Apertural Width; E-F, Body Whorl Length; F-G, Spire Length

Figure 5. Opercula. a, Concentric; b, Spiral

Figure 6. Mantle and Pneumophore (PN) of slugs.
a. *Arion*
b. *Limax*

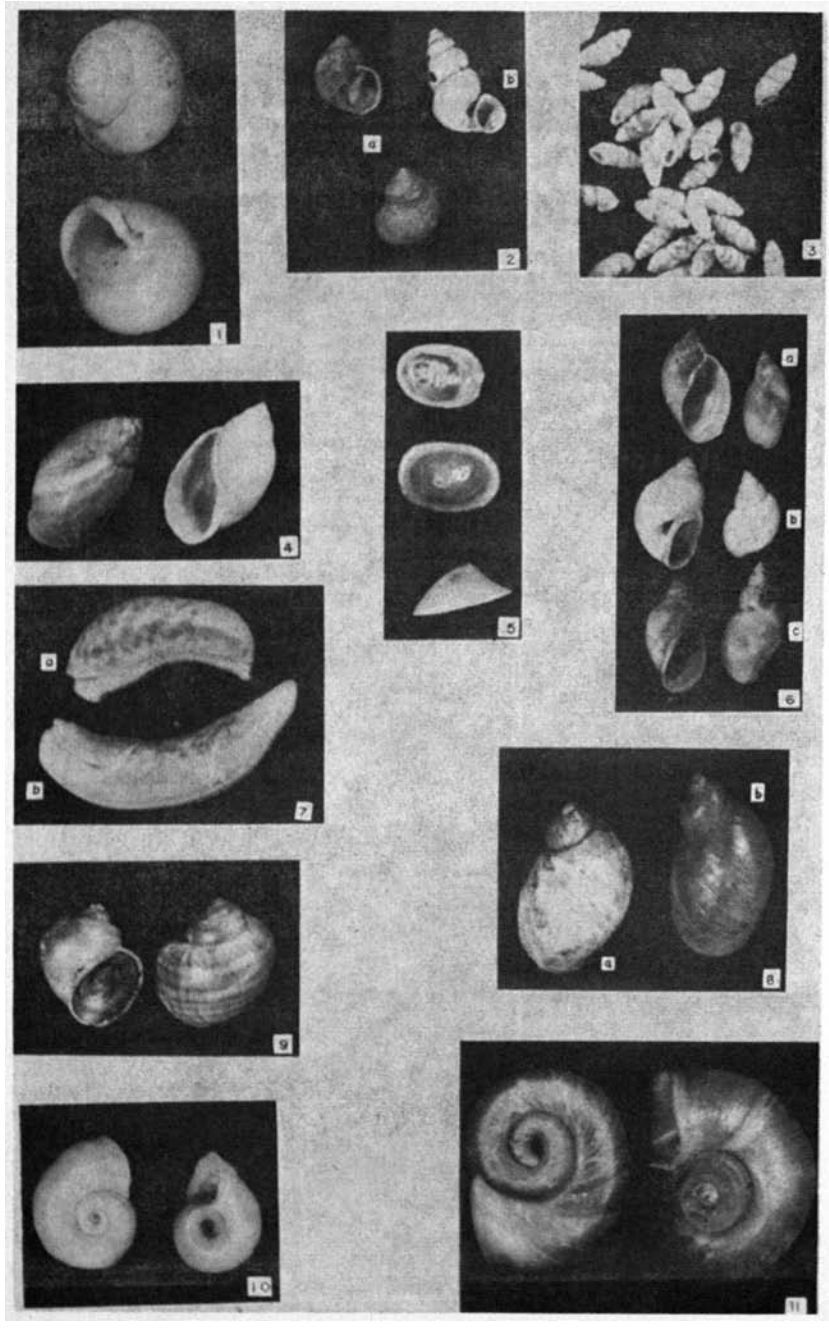

1
a
b
2
3
4
5
a
b
c
6
a
b
7
a
b
8
9
10
11

PLATE II

Figure 1. *Oligyra orbiculata tropica* (Pfeiffer) x 3

Figure 2. a. *Cincinnatia integra* (Say) x 2.3
b. *Pomatiopsis lapidaria* (Say) x 2.6

Figure 3. *Carychium exile* Lea x 4.3

Figure 4. *Physa gyrina* Say x 2.5

Figure 5. *Ferrissia tarda* (Say) x 2.3

Figure 6. a. *Pseudosuccinea columella* Say x 1.4
b. *Stagnicola bulimoides techella* (Haldeman) x 1.5
c. *Fossaria obrussa* (Say) x 1.4

Figure 7. a. *Philomycus carolinanus flexuolaris* Rafinesque x 0.25
b. *Limax flavus* Linnaeus x 0.5

Figure 8. a. *Succinea avara* Say x 3.4
b. *Succinea grosvenori* Lea x 2.8

Figure 9. *Pomacea paludosa* (Say) (?) x 0.4

Figure 10. *Helisoma anceps* (Menke) x 1.9

Figure 11. *Helisoma trivolvis* (Say) x 2

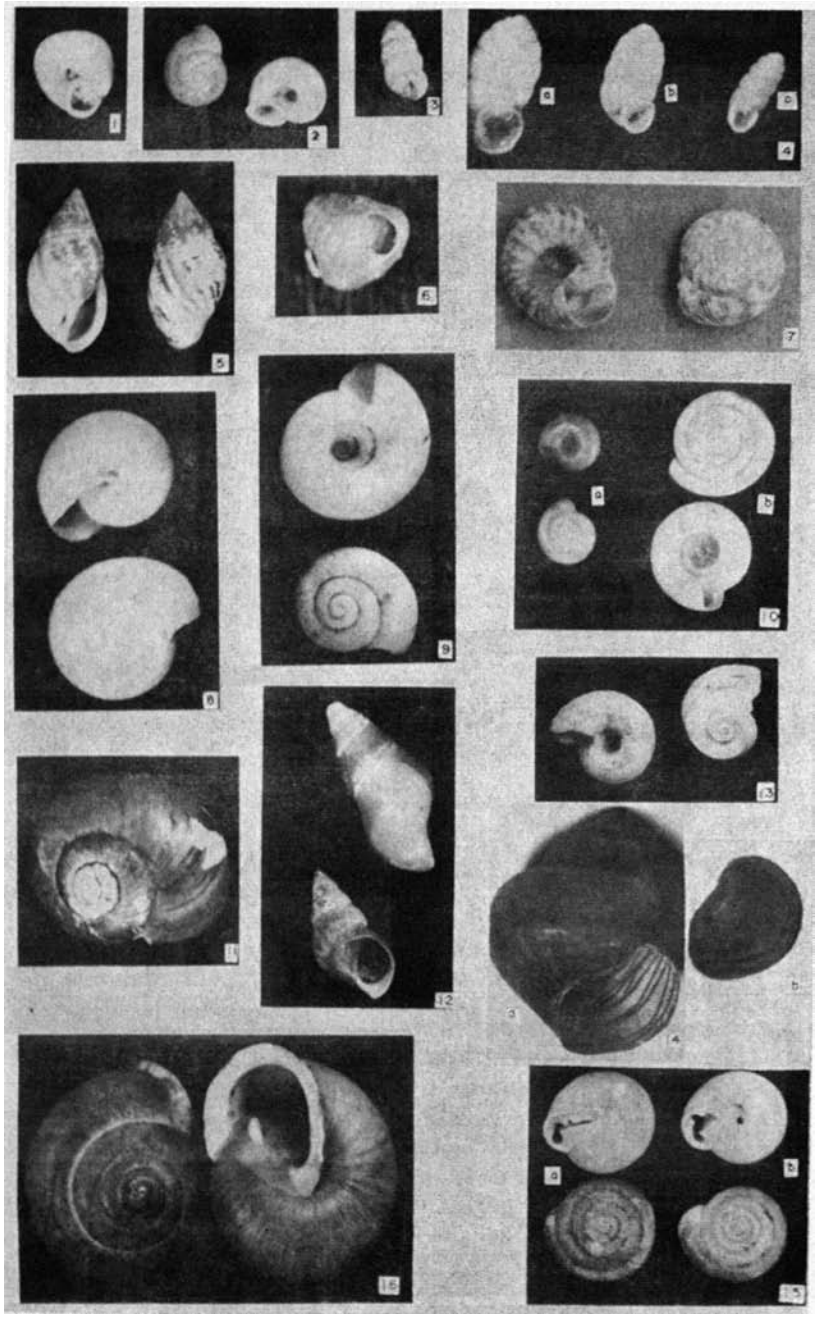


PLATE III

Figure 1. *Strobilops labyrinthica* (Say) x 4

Figure 2. *Vallonia gracilicosta* Reinhold x 4.6

Figure 3. *Columella edentula* (Draparnaud) x 4

Figure 4. a. *Gastrocopta armifera* (Say)
b. *Pupilla muscorum* (Linnaeus)
c. *Gastrocopta procera* (Gould) x 4.2

Figure 5. *Bulimulus alternatus mariae* (Albers) x 1

Figure 6. *Euconulus chersinus* (Say) x 4.4

Figure 7. *Anguispira alternata* (Say) x 1

Figure 8. *Retinella indentata* (Say) x 4.4

Figure 9. *Discus cronkhitei* (Newcomb) x 4.5

Figure 10. a. *Helicodiscus singleyanus* (Pilsbry)
b. *H. parallelus* (Say) x 5

Figure 11. *Mesomphix cupreus* (Rafinesque) x 1.4

Figure 12. *Mudalia plebia* (Lea) x 1.7

Figure 13. *Valvata tricarinata* Say x 4.2

Figure 14. *Viviparus malleatus* Reeve a, Shell; b, Operculum x 1.4

Figure 15. a. *Stenotrema stenotrema* (Pfeiffer)
b. *Polygyra texasiana* (Moricand) x 1.4

Figure 16. *Mesodon thyroideus* (Say) x 1.5